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CASE REPORT
Reconstructive

Early Experience with External Negative Pressure Delay in Free Anterolateral Thigh Perforator Flap Reconstruction

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Summary: Negative pressure therapy has been utilized in the treatment of open and closed wounds to increase blood flow and improve wound healing. More recently, external negative pressure has been shown to induce a noninvasive delay phenomenon in animal models by increasing vessel size and density within a planned flap, leading to improvement in flap survival. Although successful in animal models, this new method of delay has not been demonstrated in clinical practice. We present our initial experience with preoperative external negative pressure delay of free anterolateral thigh flaps in upper extremity reconstruction to detail the technique and safety profile of this innovative new technique. External negative pressure delay has the potential to provide results similar to those of traditional surgical delay, while being cost effective, safer, and more convenient for patients. More research is needed to investigate the clinical benefit and cost effectiveness of external negative pressure delay. *(Plast Reconstr Surg Glob Open 2021;9:e3606; doi: 10.1097/GOX.0000000000003606; Published online 7 June 2021.)*

Vasconez's second law: "all of the flap will survive, except the part that you need."[1] The delay phenomenon improves the reliability of tissue transfer by increasing flap vascularity before transfer.[2–4] Traditional surgical delay includes sectioning part of the vascular supply to a planned flap to achieve this goal.[5] Although successful, surgical delay carries additional cost, risk, and inconvenience to the patient. Likely due to these factors, Vasconez's fifth law is "do not delay flaps (unless after 5:00 pm)."[1] Attempts to increase the utility of the delay phenomenon have been explored without widespread adoption.[6–9] External negative pressure delay (ENPD) has the potential to provide similar benefits to surgical delay while mitigating these negative factors. In this non-invasive technique, a negative pressure dressing is placed over the donor site skin before surgery to induce a delay phenomenon.

The anterolateral thigh (ALT) flap has become a workhorse flap in reconstructive surgery since its introduction.[10] Although the ALT flap has been shown to be reliable, complex perforator dissection technique is required. Furthermore, there is a small subset of patients with no identifiable perforator.[11] When timing allows, we have begun routinely utilizing ENPD before ALT flap harvest in an attempt to improve the reliability and ease of harvest in upper extremity reconstruction. The existing literature on ENPD is reviewed, and our initial experience is described.

CURRENT EVIDENCE

In the first report of preoperative external negative pressure therapy, Morykwas et al found a 21% increase in flap survival in random pattern flaps that were treated with external negative pressure in a pig model.[12] Similarly, Rhodius et al found a 37% increase in vessel density and 27% increase in flap survival in random pattern flaps performed in a diabetic murine model.[13] Mohan et al performed an extensive analysis of negative pressure flap conditioning in a rodent model. They found a 2-fold increase in mean vessel volume and a 30% increase in absolute intensity when evaluated with indocyanine green angiography in preconditioned flaps.[14] Other authors have reported similar findings of increased vascularity and improved flap survival in animal models when treated with external negative pressure.[15–19]

It is unclear what the optimal treatment conditions and duration of therapy are at the present time. The most common pressure setting reported is −125 mm Hg, and both continuous and intermittent suction settings have

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been utilized.[12–16] The report time period of treatment also varies, with the most common length of treatment being 5–7 days before intervention.[12–16] We present our initial experience using ENPD in free ALT flap reconstruction of upper extremity defects.

TECHNIQUE

At the bedside, the traditional flap markings for an ALT flap are designed along the donor thigh. The skin is protected with a layer of Vaseline gauze (Adaptic; 3M, St. Paul, Minn.), and a large black wound vac sponge (KCI, San Antonio, Tex.) is externally secured to the thigh skin overlying the planned flap (Fig. 1). The dressing is connected to suction in a standard fashion. At the time of surgery, the dressing is removed and flap harvest is performed in a standard fashion.

CASE 1

A 46-year-old man with a history of obesity and hypertension sustained a degloving injury of the left upper extremity after a rollover ATV incident (Fig. 2). A free 26 × 9 cm subfascial ALT was planned for wound reconstruction. ENPD was initiated at −125 mm Hg of intermittent negative pressure for 6 days before anterolateral thigh free tissue transfer. On day 6, the flap was harvested in the subfascial plane on 2 musculocutaneous perforators (Fig. 3) and anastomosed in an end-to-side fashion to the radial artery and cephalic vein. The flap was then inset to reconstruct the defect (Fig. 4). The patient healed uneventfully and was discharged home on postoperative day 6.

CASE 2

A 20-year-old man sustained an open grade IIIb fracture of the right ulna with laceration of the ulnar artery and nerve after a high velocity ballistic injury. A free

Fig. 1. Design of the ipsilateral anterolateral thigh free flap (A) with subsequent application of vaseline gauze and wound vac sponge dressing to the planned flap harvest site (B).

Fig. 2. Dorsal degloving injury of the hand and wrist after rollover ATV accident with exposed extensor tendon lacerations and open wrist joint (open joint denoted with black arrow).

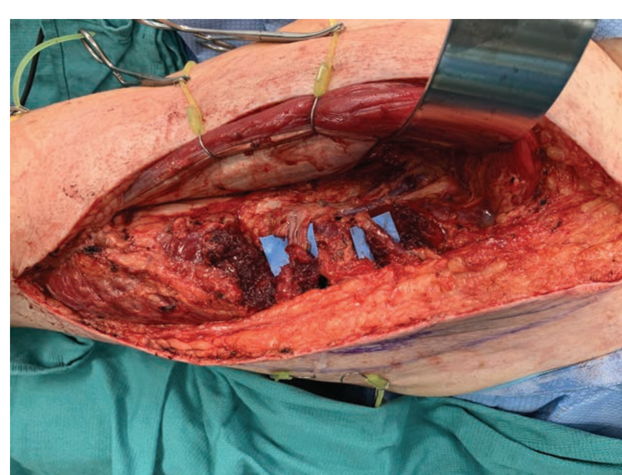

Fig. 3. Anterolateral thigh flap harvested on 2 large intramuscular perforators.

Fig. 4. Appearance of the flap after microvascular anastomosis and inset. No skin irritation was encountered during the course of external negative pressure therapy.

22 × 7 cm subfascial ALT was planned for wound reconstruction to be performed concurrently with bony stabilization and nerve graft reconstruction. ENPD was initiated at −125 mm Hg of continuous negative pressure for 6 days before tissue transfer. Intraoperatively, only 1 small septocutaneous perforator was identified that appeared to be inadequate for flap harvest. Before conversion to musculocutaneous harvest, indocyanine green angiography (SPY Angiography; Stryker, Kalamazoo, Mich.) was utilized to evaluate the perforator. There was excellent filling of the flap when isolated on this perforator, and therefore single perforator harvest proceeded. The flap was anastomosed in an end-to-end fashion to the ulnar artery and venae comitantes. The patient healed uneventfully and was discharged home on postoperative day 7.

DISCUSSION

We hypothesize that external negative pressure delay has several potential benefits in reconstructive surgery:

1. Improved reliability of a planned flap;
2. Increased amount of tissue that is able to be harvested on a single vascular supply;
3. Improved ease of harvest in perforator flap surgery;
4. Increased reliability of super-thin flap harvest and propeller flap harvest;
5. Reduced incidence of fat necrosis in large fasciocutaneous flaps;
6. Potential mitigation of patient risk factors.

In our early experience, ENPD appears to be safe when used in both intermittent and continuous fashion. There was no evidence of patient discomfort or skin irritation after treatment. Importantly, there was no evidence of posttreatment discoloration of the skin, which may be mistaken for venous congestion. There appears to be improvement in perforator quality when treated with ENPD, but further investigation is required to measure this. In the second case, we feel that ENPD prevented the conversion to musculocutaneous harvest, saving operative time and patient morbidity.

The negative aspects of this method of delay include the cost associated with the device and the need for sufficient time between initiation of therapy and the planned surgery. However, if used in the right clinical scenario, it is likely that the potential benefits far outweigh these negative factors. Further research is necessary to understand the physiologic and clinical outcomes after ENPD.

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